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POTASH FERTILIZERS.

SOURCES AND METHODS OF APPLICATION,

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PREFACE.

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Potash is usually regarded as second in importance among the fertilizing substances needed in our soils. When our farm lands were first cleared up and put under cultivation, there was an abundance of this important ingredient present in our soil in such form as to be readily available to the plants grown. But many years of cultivation have been drawing heavily upon this supply, and the advantage of applying potash in some form to the soil is known to every practical farmer.

The loss of potash from an acre of ground in a five year's rotation, if fairly good crops are grown, will amount to over two hundred pounds. The five year's rotation is mentioned because it is the rotation followed by so many farmers in this State, consisting of corn, oats, wheat, clover, and a second year's production of grass, principally, timothy. If the wheat crop amounts to twenty bushels per acre, the potash taken from the soil by the grain and straw, will be in the neighborhood of twenty pounds. If fifty bushels of corn are grown per acre, the potash taken up will be about fifty pounds, while forty bushels of oats per acre will take from the soil about fifty-five pounds. The two grass crops, if they each produce two tons of hay per acre, will take up nearly one hundred pounds of potash.

It is, therefore, clear that the matter of keeping up the supply of potash in the soil is a very important question to the farmer. This Bulletin has been prepared and is published to call attention to this question, and to point out the sources from which farmers may, with least cost and most convenience, secure the supply necessary to take the place of the potash that is being constantly removed from the soil.

N. B. CRITCHFIELD,
Secretary of Agriculture.

POTASH FERTILIZERS—SOURCES AND METHODS OF APPLICATION.

By H. J. Patterson, *Director and Chemist of the Maryland Agricultural Experiment Station.*

INTRODUCTION.

There has been considerable work done from time to time and at different places upon determining whether particular soils needed potash and the amount which should be applied to various crops; but there has not been so much work done in solving some of the underlying principles connected with the use of potash fertilizers, such as the forms in which the potash should be supplied to different crops, the effects of the different sources upon the yield and quality of the crop, and also in determining the time and manner of application.

There has been some experiments conducted at the Maryland Experiment Station upon different phases of the question and the results of these tests, together with some others which have been made in the United States and Europe, are presented and discussed in the following pages. Before taking up a discussion of the results of various experiments upon these topics, it will, probably, be best to devote a little space to a general description and consideration of the subject of potash manures, the forms in which we find potash and the various sources of the same; also to give a general historical sketch of the use of potash in agriculture.

HISTORY.

There is no definite record as to the time when potash was first used as a manure; but no doubt that part of the value which attended the use of lime* was due to its action in liberating and making potash available. From the writings of Young and Chateauvieux (1788 to 1812) we gather that the farmers in the neighborhood of Vesuvius recognized the value of the ashes which the volcano poured forth from time to time, as a fertilizer to the land; and this fertilizing value was no doubt, in a large measure, due to the potash which the ashes contained, especially from the fact that the classes of crops which they grew are relatively heavy feeders on

*According to Pliny, lime was probably used two to three hundred years B. C.

potash. Another early reference which would seem to be a recognition of the value of potash as a manure was in connection with the practices of the Flemish farmers during the eighteenth century of burning the rape, a crop which they grew largely for its seed, pods and straw for their ashes which they chiefly used as a top dressing upon clover. These ashes were so highly prized for this purpose that they brought three times the price of all other sorts of manure used at that time. The ashes of the Saltwort, called *Barilla*, which was sent near the beginning of the nineteenth century exclusively into commerce from Sicily and the east coast of Spain for use as a fertilizer, contained about five per cent. potash; and part of their value in agriculture was no doubt due to this element. Some of the good results attending the old English custom, as usually practiced, of burning land no doubt was due to the potash remaining in the ash residue. The early American settlers observed that the land upon which brush and trees had been burned had an increased productiveness. All of these observations and data would simply show that the first potash applied to land for fertilizing purposes was in the form of ashes; yet it was done without attributing the value to any one element.

It was not until after the advent of agricultural chemistry and the relation of the mineral matter of soils and plants as pointed out, first, by Saussure in 1804, and then further established and shown to be essential by the work of Sir Humphrey Davy as is evidenced by his statements in *Elements of Agricultural Chemistry*, published in London in 1814, that potash was really recognized as an essential to plants and that certain manures owed their value to this element. Springel, in his *Theory of Manuring*, published in 1839, was the second to express an opinion to the same effect. The researches of Justus Von Liebig served to show the necessity of potash to plants and it was through the publication of his results that the value of this element became generally known.

For many years the only sources of potash was ashes of plants and the nitrate of potash (saltpeter or niter) found in caves; but this latter was generally so much in demand for making gunpowder and in other arts that its price was such as to prevent its extensive use in agriculture.

In 1857, the Prussian Government made borings near the Harz Mountains for rock salt and found great quantities at Stassfurt about 1,080 feet below the surface. Immediately above this rock salt are deposits of various potash and magnesia minerals which at first were thought to have but little value and were thrown away; but very soon after this discovery the results of Liebig's investigations became generally known and the value of potash as a fertilizer

recognized. This offered a market for these potash minerals and caused a factory for the refining of them to be established in 1861.

THE ROLE OF POTASH IN PLANTS.

Essential for the Formation of Starch and Protein.

It has been firmly established that potash is of paramount importance in performing the proper functions of every living cell. Potash plays an important part in the organization of starch and also serves as a means for enabling starch to move from one part of the plant to another. It has been proven that these functions of potash are not performed because of its alkalinity but are due to some other undiscovered virtue; at all events, none of the other alkalies are competent to take its place.

In green plants the potash is concerned not only in the synthesis of carbohydrates but also in that of protein bodies, since not only is there an increase of potassium salts in such parts of green plants as are developing rapidly and consequently forming large amounts of protein, but most fungi are found to require potassium salts for the production of protein. In the absence of potash, plants will not grow and neither starch nor protein will form or move in them no matter how much of the allied alkalies (sodium, lithium, caseium or rubidium) may be offered to them. The juices of plants which are noticeably sour, such as the leaves of sorrel, stalks of rhubarb, juices of lemon, apple, gooseberries, grapes and the like, commonly contain an organic acid salt of potash.

The physiological role which potash exerts in connection with plant growth seems to be in a measure due to the peculiar chemical condensation properties possessed by this element over other elements of its group, as pointed out and discussed at length by Dr. O. Loew, in Bulletin No. 18, p. 21-28: "The Physiological Role of Mineral Nutrients," published by the Division of Vegetable Pathology, U. S. Department of Agriculture. Experiments conducted by Helreigel have shown very clearly that a certain amount of potash was necessary in order that perfect barley could be produced. The so-called clover sickness of soils has in some cases been traced to a deficiency of potash.

Soda as a Substitute for Potash.

There has been much said on this subject, as some people have made claims that soda can replace potash in the plant; but careful

experiments have proven beyond a doubt that potash is essential to plant growth and is never absent in any part of the plant, but generally present in considerable quantities. Soda has been shown to be nonessential in all cases and is often entirely absent from the grain and tuber of plants; even in cases where it has seemed indispensible a very small amount answered the requirements. There have been a few cases where soda seemed to replace potash to a slight extent, but in such instances the excessive feeding upon soda has been either mechanical or accidental. Observations upon salt marsh plants have shown that potash was essential and that they responded to potash fertilization. In cases where increased yields and general good results have followed the application of common salt (sodium chloride), the good results have been due to its action as an indirect fertilizer by rendering the plant foods already in the soil available and gives beneficial effects upon the physical condition of the soil and cannot be attributed to the soda being used as a food by the crop.

Quantity of Potash Annually Removed from Pennsylvania Farms.

In order to convey some idea of the great drain of potash from the farms of Pennsylvania, the figures in Table I have been compiled, showing that which is removed by the staple crops. Though large as these figures may seem, yet they represent but a part of what is taking place The amount removed by the many million dollars worth of truck crops, small fruits, orchard fruits and forest products annually sold from Pennsylvania farms is not accounted for in the table. Again, the live stock, poultry and eggs carry considerable potash with them. The total amount of potash removed by the crops, as exhibited in Table I, of 266,972,050 pounds would require, if it were to be replaced, over 266 thousand tons of standard Muriate of Potash, or over one million tons of kainit. This would mean an expenditure of over ten million dollars annually for potash alone.

TABLE I.

The Approximate Quantity of Potash Annually Removed from Pennsylvania Farms by the Principal Crops.

Crops.	Bushels.	Pounds.	Potash, per cent.	Pounds of potash.
Barley,	197,179	9,464,524	0.48	45,430
Barley straw,	....	15,389,690	2.09	321,614
Buckwheat,	3,922 980	188,295 240	0.21	395,420
Buckwheat straw,	....	320,101 908	2.42	7,746,466
Corn fodder,	....	5,809,415,360	1.40	81,331,815
Corn, grain,	51,869,780	2,904,707,680	0.40	11,618,830
Oats,	37,242,810	968,313,060	0.62	600,352
Oat straw,	....	1,646,132,202	1.24	20,412,039
Rye,	3,944,750	220,906,000	0.54	1,192,392
Rye straw,	....	375,540,200	0.79	3,056,768
Wheat,	20,632,680	1,227,960,800	0.61	7,551,560
Wheat straw,	....	2,104,533,360	0.51	10,733,120
Potatoes,	21,769,472	1,209,090,430	0.29	3,535,362
Sweet potatoes,	234,724	13,144,544	0.37	48,634
Onions,	347,806	19,477,136	0.10	19,477
Tobacco (lbs.),	41,502,620	41,502,620	3.81	1,571,250
Beans,	23,957	1,341,592	1.26	16,904
Peas,	6,363	356,328	1.00	3,563
Hay and forage (tons),	3,766,834	7,533,668,000	1.55	116,771,854
Total,	....	....	....	266,972,050

The figures given in Table I show something as to what is taking place in the State at large, but the figures are so large that they are somewhat bewildering; so in order to present an idea of the amount of exhaustion of potash by crops in a little different way and upon a basis which is more easily applicable to the cropping on each farm, calculations have been made of the quantity of potash removed from one acre by a fair yield of some of the commoner products. These figures are presented in Table II:

TABLE II.

Approximate Quantity of Potash in the Product of One Acre of Sundry Farm Crops.

Estimated Crop.	Potash, lbs.	Value of potash, cts.	Equivalent in muriate of potash, lbs.
Corn, 50 bushels,	10.4	52	21
Oats, 40 bushels,	7.9	39	16
Wheat, 25 bushels,	7.8	39	16
Potatoes, 150 bushels,	52.2	261	104
Tobacco, 800 pounds,	32.5	162	65
Tomatoes, 10 tons,	53.8	269	107
Clover hay, 2 tons,	74.4	372	149
Timothy hay, 2 tons,	81.0	405	162
Wheat straw, 1¼ tons,	15.7	78	31
Silage fodder, corn, 15 tons,	111.0	555	222

The figures given in the above table are not intended to show the amount of potash needed for the growth of the whole plant or crop, but simply what would be removed in the parts which are generally sold.

Though these figures in some cases seem very small, in fact almost insignificant, yet when the fact is considered that these amounts of potash are being removed annually and, under some systems, oftener, and that most of the lands have been under cultivation for a considerable length of time, it will be realized that even these small amounts represent a great drain upon the land when multiplied by 10, 20, 50 and even 100 or more crops.

Anyone interested to caluclate out the amount of potash removed by any particular crop can obtain the potash content of most agricultural products by referring to Table I, page 10, Bulletin No. 94 of this Department.

Relative Quantity of Potash in Different Parts of Plants.

In cereal crops about four times as much potash is removed in the straw as in the grain, while in peas and beans and other crops of that kind the straw contains about twice as much as the seed. This is an important fact to be considered in the use and saving of the straw for feeding and manure.

The Origin of Potash in Soils.

From what has been said it is seen that potash is absolutely necessary for the growth of plants. Indeed, there must be a fairly

large supply of this element within reach in order that plants may prosper.

There is, naturally, a good deal of potash in the soil, as follows necessarily from the fact of its occurrence in the ashes of plants. The potash naturally present in the soil in common with its other mineral constituents, has been derived from the decomposition of the original rocks. The soils which are richest in potash are those which have been derived from rock rich in potash-feldspar, but much potash is also derived from mica, glauconite, and other minerals, and even limestones furnish a small amount. In original rocks the potash is chiefly united with silica in more or less complex unions and wholly insoluble in water. In the decomposition of these rocks some of the potash is rendered soluble and lost by the leaching produced by heavy rains, but with the remaining portion there is not much chemical change so that the potash is still held in the insoluble state, but, nevertheless, so finely divided and in such a mechanical condition as to yield gradually to the demands of the growing plants.

Amount of Potash in Rocks.

As has already been noted, soils derive their potash from the decomposition of rocks. The rocks supplying the most potash to soils are those which contain considerable of the potash-feldspar. The rocks containing this mineral are widely distributed. Feldspar itself is chiefly a silicate of alumina associated with the silicates of potash, sodium or calcium. The predominating alkali is either potash or soda. Either of these alkalies may predominate, but there will always be found associated a small amount of the other. The amount of potash in feldspar varies from 5 to 17 per cent. Some of the best are those found at French Creek Mines, Warwick, Pa., which contain about 16 per cent. potash; at Magnet Cove, Arkansas, 15.6 per cent. potash, and at Leverett, Mass., 12.2 per cent. potash. These potash feldspars contain as much potash as the kainit of commerce, but, unfortunately, their potash is insoluble in water and there is no economical means of rendering the potash available.

Many of the volcanic rocks are rich in potash and as they decompose readily, have been used as a source of potash. Mica contains from 3 to 5 per cent. potash; clay slate 1 to 4 per cent.; basalt 3-4 to 8 per cent. These are all double silicates. The "green sand" marls, which are widely distributed along the Atlantic coast and found in extensive deposits often mixed to a greater or less extent with the shell marls, contains a mineral called glauconite which is rich in potash. The marls vary from nothing to nearly 5 per cent. potash.

When these marls contain considerable shells, they can be burned for lime and at the same time this process will cause the potash to become available to crops more quickly.

The Quantity and Distribution of Potash in Soils.

From what has been said as to the origin of soils and the variation in the composition of the potash minerals, it is evident that soils will vary considerable as to their richness in potash.

The typical soils of Maryland, as analyzed and reported upon in Maryland Station Bulletin No. 70, show a variation of 1-10 to 4 per cent. of potash.

An acre of soil such as was used for the potash experiments by the Maryland Station, reported upon in this bulletin, weighed to the depth of six inches, about 1,812,964 pounds which, with a soil containing about one per cent. of potash, would mean that such a soil contained about 18,000 pounds or 9 tons of actual potash. Such a soil would have enough potash in the six inches of surface soil, alone, to grow crops of wheat of 25 bushels each for over 700 years before the potash would be entirely exhausted.

The relative quantity of potash found in surface and sub-soil varies in different formations and also with the character of cropping and cultivation which has been pursued, but generally there is more in the sub-soil than in the surface soil. This fact is important as it shows the necessity for adopting such a system of culture and cropping as will contribute towards bringing some of the potash up to the upper layers of soil.

Condition or State of the Potash in the Soil.

Potash exists naturally in soils in a condition which is insoluble in water and even the very soluble potash salts which are supplied in commercial fertilizers sooner or later form combinations in the soil which are no longer entirely soluble in water. It is probable that most of the potash in soils which is immediately available to crops exists in combinations commonly designated as hydrated double silicates or in that of double humates. In very rich soils and in those recently fertilized some soluble potash salts will be found clinging to particles of soil by adhesion. While a small amount of the potash silicates and humates are soluble in water, yet they are chiefly made available to crops through the agency of the carbonic acid waters of the soil and through the agency of acid solutions which exude from the roots of plants. These facts emphasize the need for organic matter in soils so as to furnish the humates and to charge the soil waters with carbonic acid.

Conditions Affecting the Availability of Potash.

We have already seen that the form or combination in which the potash exists has much to do with its availability. The degree of fineness of the soil particles also affects its solubility and hence its availability to plants. The clay, therefore, generally possesses the highest degree of solubility decreases with the coarseness of the particles. These coarse particles will be gradually broken up and disintegrated by the action of the elements and thus the plant-food will become gradually available in the course of years.

Thus, it is seen that nature guards her storehouse of potash from rapid consumption and yields up only limited portions each year. This is also true in respect to the other plant-foods. This seems to be a very wise provision, for no doubt should science discover methods of rendering the plant-foods available rapidly and in unlimited quantities, that aggressive agriculturists would not hesitate to take advantage of the opportunity and consume it at once.

However, there are some methods which farmers can use to make the potash stores of the soil more readily available to crops; the chief of which is the growing of crops which have a great ability to feed on elements which are unavailable to most plants and this may be termed digestion of plant-food. By filling the lands full of organic matter and thus aid in the forming of humates and charging the soil-waters with carbonic water. And also by applying such materials as lime, phosphates, salt, etc., that will facilitate the formation of the double silicates. With potash, as well as with other fertilizing materials, it is necessary, in addition to what has already been said, to always provide for good drainage and then to use good cultural methods so as to insure the proper aeration of the soil.

General Conditions Indicating the Need of Potash.

In general, the fertility of land is determined by the least abundant fertilizing principal, not by the most abundant. It is more important for plants to be furnished a well-balanced ration than it is for animals; for, in fact, within very narrow limits, a plant will consume only a balanced ration and when the supply of material necessary for balancing its ration is exhausted it does not attempt to substitute anything else but simply stops growing. Consequently, it is only when the other needed plant-foods are present in the proper proportions that satisfactory results can be expected to attend the application of potash or any other fertilizer. Numerous experiments in this country have shown the force of these statements and that there was no use in expecting one pound of plant-food to do the work of two pounds. This primary condition is fre-

quently neglected, partially owing to indifference and partially because of the difficulties attending the determination of the requirements of the soil. Whether a given soil may require the addition of potash to arrive at its maximum fertility may be determined by experiment, or in a measure, by analysis.

When the total amount of potash as determined by analysis falls below one-tenth of a per cent. it is a fairly sure indication of the need of potash. Nevertheless, soils which show plenty of potash by analysis may still be deficient in this element as it may be in an unavailable condition. In such case it will be necessary to adopt means of rendering the amount present available and supplementing it by applications until this condition is arrived at. The general character and origin of the soil gives some indications as to the potash requirements. Reclaimed marshes, vegetable soils, light sandy soil and soils of water or "drift" formation are almost always uniformally deficient in potash. A mechanical examination of soils also gives some indication of their richness in potash; since as the content of clay increases there is generally a corresponding increase in potash due to the fact that both clay and potash are derived from the decomposition and breaking down of silicates. Certain phases or kinds of so-called "clover sickness" in soils is due to an insufficient supply of potash. The kind of cropping to which soils have been extensively subjected also gives some indication as to the probable deficiency of potash, as for instance, land which has grown many crops of tobacco, potatoes or beets.

How Far can Chemical Analysis of Soil Indicate Potash Requirements.

The chemical determination of the amount of potash in a soil is useful in showing what course should be pursued in the matter of cultivation and fertilizers. If a soil shows a considerable per centage of potash by analysis it indicates pretty clearly the probable course which should be pursued. In the first place, there would probably be no need of artificial applications of potash; yet if the plants showed a deficiency in potash then it would be pretty evident that some methods of culture and application should be made which would render the existing potash available to the crops. Lime, plaster and dissolved phosphates are agencies which will aid in making potash available, and such crops as peas, beans, clover and vetch can feed on potash which would be unavailable to wheat, corn and timothy. Fall plowing and other cultural methods are aids in the decomposition of potash minerals.

Considerable effort has been made to determine the difference between available and unavailable potash, but nothing very satis-

factory has been arrived at. Experiments of some German investigators seem to indicate that for most cereals the soil should contain at least two-tenths of one per cent. of potash soluble in 10 per cent. hydrochloric acid. Hilgard, of California, as a result of a great deal of work on the soils of the south and west gives the following figures as the amounts which should be soluble in strong hydrochloric acid in soils of various characters:

Potash: In sandy soils of great depth may be less than 0.1 per cent.; in sandy loams, 0.3 to 0.1 per cent.; in loams, 0.45 to 0.3 per cent.; in heavy clays and clay loams, 0.80 to 0.45 per cent.

Kinds and Sources of Potash Fertilizers.

From the facts which have been presented it is very evident that potash is one of the essential constituents of plants, and that while some soils are naturally deficient in this element, others are becoming so through the system of cultivation and cropping to which they are being subjected. These two conditions make it necessary to have recourse to the application of potash to a greater or less extent in most agricultural sections. In order to use potash intelligently when needed it is desirable to know something of the nature of the different sources available for furnishing this supply; so before taking up the experiments conducted with various potash fertilizers, a little space will be given to a detailed description of the principal potash manures on the market.

German Potash Salts.

Most all of the potash used for fertilizing purposes, not only in this country but in the world, comes from the Stassfurt mines in Germany and are popularly designated as German Potash Salts. There are a variety of these salts varying in composition and amount of potash which they furnish. A brief history of the origin and a description of these salts will be given in the following pages:

Origin of the Stassfurt Potash Deposits.

The following is the description of the origin of this deposit as given by the German Kali Works and published in the pamphlet, entitled "Stassfurt Industry."

"The Stassfurt salt and potash beds were formed or deposited in ancient, geological times. Long before history begins these minerals were laid in place by the evaporation of sea water confined in lakes, which, somewhat like the Dead Sea and Baikal Lake, were without outlet. These were connected with the ocean by channels, ordinarily dry but through which the sea water was forced at times

by great storms and tides. In this way fresh supplies of salt were received into these lakes, and, as the climate of Europe was tropical during this formative period, the surface evaporation of the water was exceedingly rapid. As the water levels of these lakes thus sank, fresh supplies pushed in from the sea, holding in solution, then, as now, many salts. Evaporation carries off only pure water, so, in course of time, as more salts were entering the lakes and none going out, the water became saturated with salts until those least soluble in water began to separate from the more soluble ones and deposit themselves in more or less uniform strata. By such continued evaporation and ever increasing concentration these immense layers of rock salt and anhydrite (sulphate of lime) were formed. As the rock salt separated and the concentration became greater, other more soluble salts began to deposit and cover it, layer upon layer, up through the mineral polyhalite, which is composed of sulphate of lime, potash and magnesia,—Kieserite, which is sulphate of magnesia,—and the 'potash region,' the stratum of carnallite, a compound of chlorides of potassium and magnesium. This last named stratum ranges from 50 to 130 feet in thickness, and supplies the crude salts from which the most important and concentrated potash salts are refined.

"From thus referring to strata it does not follow that these deposits are in smooth, clear-cut layers. From time to time, as additional water came in from the sea, the lake water became so diluted that precipitation was arrested to a certain extent and later, had to commence again; thus anhydrite is found in the rock salt strata, and seams of rock salt in the polyhalite and other upper layers. Potash and magnesia salts are the most soluble and, therefore, naturally found at the tops of the deposits.

"Had these deposits been exposed to the action of rain water they would have been dissolved, but they were protected during geologic changes by covering of 'salt clay,' impervious to water. Above this salt clay roof occurs a deposit of anhydrite beneath a second deposit of rock salt—a later formation and probably of recent origin, geologically speaking. The depth of the Stassfurt salt deposit, from the top of the upper to the bottom of the lowest stratum is some 5,000 feet. The beds underlie the extensive country reaching approximately to Thuringia on the south, to Hanover on the west and to Mecklenburg on the north.

"These deposits, in the order of their placing, follow well understood physical and chemical laws; and yet local conditions and geologic disturbances fixed the relative positions of strata and account for more or less apparent disturbances. At a few places surface water found access through cracks or fissures, and either carried

away potash salts or changed them into secondary products; from which action in the upper strata occur beds of kainit, sylvanite, hartsalz, and other compounds of less importance."

This description, somewhat tedious to unscientific readers, becomes of surpassing interest when the enormous importance of the formation is considered. But for these peculiar conditions at Stassfurt (conditions generally termed accidental) these potash deposits could not have been formed; and vast tracts of agricultural lands, now made fertile and productive by the use of potash from this inexhaustible store, would be sterile and barren for want of it. There is no question as to this scientific fact, and thoughtful readers may well again peruse the story of these wonderful deposits and question whether a formation—all but a creation—of such importance to the human race, can be considered a mere chance—a simple accident of nature.

DESCRIPTION OF THE POTASH SALTS.

Natural Products of the Mines.

Salt is the chemical name for a compound composed of an acid joined to, or combined with, a base. For example, burnt lime is a base, which in combination with sulphuric acid, forms a salt called sulphate of lime; similarly the base, sodium combined with hydrochloric acid forms the salt, sodium chloride. This last is the compound to which, popularly, the word "salt" is applied, for sodium chloride is our common table salt, but chemically the term is a general name for compounds produced as described above. The Stassfurt deposits contain various salts and combinations of salts, many of which contain little or no potash. The following list gives those most important as potash producers, with their mineral names, and chemical formulae:

Carnallite, $KCl, MgCl_2, 6H_2O$.

Kainit, $K_2SO_4, MgSO_4, 6H_2O$.

Sylvanite, $KCl, NaCl, K_2SO_4, MgSO_4, MgCl_2, 6H_2O$.

Hartsalz; $KCl, NaCl, MgSO_4, H_2O$.

Upwards of thirty different minerals are found in the Stassfurt deposits, of which some twelve contain more or less potash. The four above named yield the main supply of commercial potash, and of these the first three are most important.

Kainit.

The most important of the natural salts of potash for fertilizing purposes is the mixture, known as kainit. This is a compound of

the sulphates of potash and magnesia with magnesium chloride. In a pure state it would contain. theoretically, 16 per cent. of potash. The pure salt, however, is not found in commerce. It occurs in large irregular deposits, and as mined, it is usually of a reddish color and more or less mixed with common rock salt (of which it contains about 30 per cent.), potassium chloride, gypsum and other impurities. In its crude state it is largely used as a fertilizer, after being crushed and ground. The content of potash in the commercial kainit is about 12.5 per cent., of which more than one per cent. is derived from the potassium chloride (muriate of potash) present. Most of the kainit mined is sold in its natural state for fertilizing purposes, although a considerable part is used for the manufacture of high grade sulphate of potash and other concentrated products.

Kainit is a valuable source of potash, but has the disadvantage of being less concentrated than some of the other salts and consequently costs relatively more because of freight and handling of so much undesirable matter. For most crops kainit is a valuable source of potash, but on such crops as tobacco it should never be used as the chlorine which it contains injures its quality. Kainit is generally considered to be particularly valuable on light sand and peat soils as it has a tendency to keep the soil compact and thus retain moisture. Kainit is considered to have special virtues in preventing some kinds of blight and the ravages of some insects.

Carnallite.

This mineral is the most abundant of the natural deposits of potash. It is a mixture of potassium and magnesium chlorides and is the chief source of muriate of potash and other concentrated salts. It occurs mixed with rock salt and other minerals in layers averaging about 85 feet in thickness. The color varies and shades through semi-transparent, and white, bright to dark red, yellow and light to dark gray. Commercial carnallite has slightly less potash than kainit, containing about 9 per cent. of actual potash. It is seldom used in its crude state for fertilizing purposes except in localities near the mines. It absorbs water freely from the atmosphere and is consequently difficult and disagreeable to handle.

Sylvanite.

Considerable quantities of this mineral have been mined in recent years. It is, in the main, a mixture of sodium and potassium chloride or rather of a mineral known as sylvine which is a pure potassium chloride and of rock salt which is sodium chloride. It also contains some kainit and other impurities. It contains from 14 to 18

per cent. of actual potash in the form of the chloride (muriate). It is finely ground and used as a fertilizer or is manufactured into concentrated potash salts.

Hartsalz.

This mineral is a mixture of sylvanite and kieserite and is called hartsalz or hardsalt. It is found in the mines which have been recently opened and seems to take the place of kainit. Hartsalz differs in chemical structure from kainit but is of almost the same composition and for most purposes is identical with it.

Polyhalite.

This mineral occurs in the Stassfurt deposits and consists of a mixture of potassium, magnesium and calcium sulphates. On account of being practically free from chloride it would be very valuable for fertilizing crops, such as tobacco, which are injured by chlorine; but unfortunately it does not occur in sufficient quantities to become of much commercial importance. It is found only in pockets or seams among the other deposits. It contains about 15 per cent, of actual potash.

Kreugite.

This mineral occurs associated with polyhalite and differs from it in containing about twice as much calcium sulphate (gypsum) and frequently mixed with some common salt. It contains about 10 per cent. actual potash but has not much commercial importance, at least from a fertilizing standpoint.

Schoenite.

This is a mineral composed of the sulphates of potash and magnesia and contains about 27 per cent. of actual potash. It is specially valuable for fertilizing tobacco and vineyards, but on account of the deposits being very limited has not much commercial importance.

Kieserite.

This mineral is really only a magnesium sulphate and does not contain any potash of itself, but as mined has some carnallite mixed with it. In this condition it contains about 7 per cent. actual potash.

Manufactured or Concentrated Potash Salts.

In order to facilitate handling and to save the cost of transportation, most of the Stassfurt minerals are purified and concentrated.

This also in some instances makes the salts better adapted for fertilizing special crops. The principal manufactured salts sold for fertilizing purposes are the muriate, sulphate and carbonate of potash.

Muriate of Potash.

This is the richest and most soluble of the potash salts. It is also the cheapest source of potash. This is largely due to it being a concentrated article and thus making a relative saving in transportation expenses. One-half its weight is pure potash. Muriate is the principal source of potash employed in commercial fertilizers and is well suited for most agricultural crops. It contains considerable chlorine, about 46 per cent. which substance injures the burning and curing quality of tobacco for which crop sulphate should always be used.

Sulphate of Potash.

This is produced by the purification of some of the potash minerals previously described. This form of potash is preferable on heavy soils and is particularly well adapted for tobacco on account of the absence of chlorine. Many farmers also prefer sulphate of potash for potatoes, beets, fruits and tender vegetables as it forms a better quality. Sulphate of potash contains 48 to 50 per cent. actual potash.

SULPHATE OF POTASH AND MAGNESIA.

Doubled Manure Salt.

This is another of the salts produced in the manufacture or preparation of the Stassfurt minerals. It is free from chlorine and thus can be used for the same crops as the sulphate of potash. It is a less concentrated form of potash, containing only about 25 per cent. actual potash.

Calcined Potash or Manure Salt.

This salt is not found extensively in our markets. It is produced by a system of purification and concentration of some of the Stassfurt minerals. It contains 15 to 20 per cent. of actual potash, but otherwise has about the same composition and produces about the same effect upon plant as kainit.

Carbonate of Potash and Magnesia.

This is a form of potash that has been specially prepared with reference to fertilizing tobacco, but is also serviceable for all crops where intensive culture is being practiced and where it is feared that

chlorides and sulphates would be injurious. This compound is a dry powder which makes it easy to apply or mix with other materials. It contains about 18 per cent. actual potash.

Silicate of Potash.

This is another potash salt that has been especially prepared for tobacco fertilizers. It has not been placed regularly upon the market. The results of experiments conducted so far are not very decisive as to its values. It contains about 21.5 per cent. of actual potash (K_2O), 19.4 per cent. of which is soluble in water.

The average composition of the German potash salts described in the preceding pages are summarized in the following table:

TABLE IV.

Average Composition of Stassfurt Potash Minerals and Salts.

Name of Salts. In 100 Parts are Contained:	Sulphate of potash. K_2SO_4	Muriate of potash. KCl	Sulphate of magnesia. $MgSO_4$	Chloride of magnesia. $MgCl_2$	Chloride of sodium. NaCl	Sulphate of lime. $CaSO_4$	Matter insoluble in water.	Water.	Calculated to pure potash K_2O. Average.	Guaranteed.
A. CRUDE SALTS. (Natural Products.)	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Kainit,	21.3	2.0	14.5	12.4	34.6	1.7	0.8	12.7	12.8	12.4
Carnallite,	....	15.5	12.1	21.5	22.4	1.9	0.5	26.1	9.8	9.0
Sylvanite,	1.5	26.3	2.4	2.6	56.7	2.8	3.2	4.5	17.4	12.4
Polyhalite,	28.9	....	19.9	....	....	45.2	....	6.0	14.2	....
Kreugite,	18.6	....	14.7	....	1.5	61.0	....	4.2	9.5	....
Schoenite,	50.4	....	34.0	....	2.5	....	....	11.0	27.2	....
Kieserite,	....	11.8	21.5	17.2	26.7	0.8	....	20.7	7.0	....
B. CONCENTRATED SALTS. (Manufactured Products.)										
Sulphate of Potash, 96 per cent.,	97.2	0.3	0.7	0.4	0.2	0.3	0.2	0.7	52.7	51.8
Sulphate of Potash, 90 per cent.,	90.6	1.6	2.7	1.0	1.2	0.4	0.3	2.2	49.9	48 6
Sulphate of potash-magnesia,	50.1	....	34.0	....	2.5	0.9	0.6	11.6	27.2	5.9
Muriate of potash, 90-95 per cent.,	....	91.7	0.2	0.2	7.1	....	0.2	0.6	57.7	56.8
Muriate of potash, 80-85 per cent.,	....	83.5	0.4	0.3	14.5	....	0.2	1.1	52.7	50.5
Muriate of potash, 70-75 per cent.,	1.7	72.5	0.8	0.6	21.2	0.2	0.5	2.5	46.6	44.1
Manure salt, min. 20 per cent. potash,	2.0	31.6	10.6	5.3	40.2	2.1	4.0	4.2	21.0	20.0
Manure salt, min. 30 per cent. potash,	1.2	47.6	9.4	4.8	26.2	2.2	3.5	5.1	30.6	30.0
Carbonate of potash and magnesia,	....	....	....	....	....	....	....	....	18.0	....
Silicate of potash,	....	....	....	....	....	....	....	....	....	....

OTHER SOURCES OF POTASH FERTILIZERS.

Every farm produces some materials that contribute more or less to the supply of potash fertilizers—such as stable manure, the straw of cereals and legumes, beet tops, potato vines, and tobacco stems; but these, though by-products, are really only agencies for converting soil fertility which the farm already possesses. The only other sources of potash that are of any commercial importance are wood ashes, tobacco stems, cottonseed hull ashes, and potash nitrate.

Wood Ashes.

This is practically the only American source of potash that is abundant enough to be of any commercial importance, and this supply is now so limited as to restrict their use. Potash in wood ashes is the most valuable form of the carbonate. Wood ashes, besides furnishing about 5 per cent. potash, also contain one to two per cent. of phosphoric acid and 30 to 35 per cent. of lime, which are also valuable as fertilizers. The quality of ashes varies considerably with the kind of wood used to produce them and the care with which they are preserved. The difference in quality is so great without any change in appearance that the only safe way to purchase is upon guaranteed analysis.

Good wood ashes which have not been exposed to the weather or otherwise wet, such as may be described as house ashes, weigh about forty-eight pounds to the bushel and carry about 8 per cent. potash and 2 per cent. phosphoric acid. Canada unleached wood ashes as sold by the carload are rated at 45 pounds to the bushel and run from 4 to 6 per cent. of potash and about one per cent. phosphoric acid. Leached or weathered ashes are much less valuable as they contain only one or two per cent. potash.

Cottonseed Hull Ashes.

These come from the cotton oil factories of the South, where the hulls removed from cottonseed in the process of extracting the oil are afterwards used to some extent for fuel. In recent years much of the cottonseed hulls have been used for cattle food purposes and some has been finely ground and used for adulterating cottonseed meal. This has caused much less to be used for fuel than was the case some years ago, so that the supply of the ashes is quite limited. These ashes range from 18 to 30 per cent. of potash and 5 to 10 per cent. phosphoric acid. They are, therefore, highly soluble for fertilizing purposes and have been much sought by fertilizer manufacturers who keep them so closely bought up that they are seldom found on the general market. Cottonseed meal, which is largely used

in mixed fertilizers in some sections, supplies some potash as well as nitrogen and phosphoric acid.

Tobacco Stems.

The stems and stalks of tobacco which are waste products in manufacturers are rich in potash. It contains from 6 to 7 per cent. of potash and about 2 per cent. nitrogen, with about one-half of one per cent. of phosphoric acid. It thus could really be termed a complete fertilizer in itself. For best results the stems should be finely ground before application. Tobacco stems are also useful for making spraying solutions and for applying to land to prevent insect ravages. They are also used extensively for smoking greenhouse crops to kill insect pests.

Nitrate of Potash.

Nitrate of potash is the true saltpetre of commerce. It is rich in both nitrogen and potash and would be a valuable source of plant food were it not for the fact that its supply is limited and it has many other uses in the arts which cause the price to be too high for fertilizing purposes. This was an important source of both nitrogen and potash before the discovery of the Stassfurt potash salts. Most of the nitrate of potash is found in caves; but in recent years there has been numerous reports of the discovery of extensive deposits in Africa, but up to this time not enough has come on the market to materially change the price.

Miscellaneous Sources of Potash.

There are a few sources of potash that may be available at times and which would be valuable under local conditions, yet they are not of any commercial importance.

Brick-kiln ashes have some value for potash, yet are generally of poor quality as they are produced from soft woods and are much mixed with clay and brick dust.

Lime-kiln ashes are still poorer, as a rule, in potash, being mostly lime dust.

Coal ashes contain a trace of potash and lime, but are really of no value as a fertilizer except as benefiting some lands by giving them a better mechanical condition.

The Green Sand Marls of New Jersey contain a good deal of potash, sometimes as much as five per cent. The potash is in an insoluble condition and not readily available to plants.

The Maryland Marls that have been examined showed from two to four per cent. of potash, although insoluble.

For convenience, the composition of the sources of potash other than the Stassfurt salts are summarized in the following Table:

TABLE V.

Composition of Miscellaneous Sources of Potash.

	Water.	Potash.	Phosphoric acid.	Nitrogen.	Lime.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nitrate of potash or saltpetre,	2.0	45.0	....	13.0	....
Wood ashes (unleached),	12.0	5.5	1.8	....	34
Wood ashes (leached),	....	1.1	1.4	....	....
Cottonseed hull ashes,	7.0	21.0	7.5	....	10
Tobacco stems,	10.6	6.4	0.6	2.3	4
Spent tan bark ashes,	6.3	2.0	1.6	....	33
Waste from gunpowder works,	2.7	18.0	....	2.4	1
Black residuum or ash,	....	7.4	0.4	....	....
Mixed stable manure,	....	0.6	0.3	0.5	0.7
Hen manure,	....	0.8	1.5	1.6	0.2
Cow urine,	....	0.5	....	0.6	....
Horse urine,	....	1.5	....	1.5	....
Hog urine,	....	0.1	0.8	0.4	....

EXPERIMENTS CONDUCTED WITH POTASH FERTILIZERS.

Description of Tests and Land.

As has already been stated, the object of the experiments conducted with potash and which are now about to be discussed was not simply making a test as to whether a particular piece of land required potash, nor was it for the purpose of determining the limits of profitableness or productive capacity of various applications. The experiments had for their object the studying of some of the underlying principles surrounding the use of potash fertilizers as to their time and method of application, their relation to other plant foods and ingredients which enter into the different sources of supply, and to make a general study of the effect of potash on the quality of the crop.

These experiments were inaugurated in 1897, and up to this time six crops have been removed. The land used for these tests is located north of the Maryland Experiment Station buildings and in the same field with the phosphoric acid and nitrogen series of plots. The land is a medium stiff clay loam, and though quite level, has a pretty good drainage. This piece of land to all appearance was fairly uniform in character yet the yields shown by the nothing plot in these experiments indicated that there was considerable difference. There seemed to be a gradual decrease in natural productiveness from Plot 5 to Plot 26.

The previous cropping of this land, so far as known, was as follows: In 1888 there was a poor stand of grass and weeds. This was plowed down and seeded to wheat in the fall. There was timothy and clover seeded in the wheat. Wheat harvested in 1887 gave 8½ bushels per acre. Grass in 1890-91. In 1892 in corn. Spring of 1893 the corn stubble was harrowed and seeded to crimson clover. This was turned under and seeded to wheat in the fall. Wheat cut in 1894, timothy and clover was seeded in the wheat. In 1895 and 1896 the grass in this field was cut for hay. The sod was plowed in November, 1896 and potash plots laid out the following spring.

The following is the program of the experiments conducted:

PROGRAM OF POTASH EXPERIMENTS.

TABLE VI.

Plots one-tenth of One Acre Each.

The quantity of material applied was such as to give each plot at the rate of 50 pounds of actual potash per acre.

Plot No.	*Kind of Fertilizer.*
1.	Kainit (a) applied just before planting.
2.	Kainit (b). { For spring crops, applied in fall. For fall crops, applied in spring.
3.	Muriate of potash, applied as (a).
4.	Muriate of potash, applied as (b).
5.	No potash.
6.	Sulphate of potash and magnesia, double manure salt, applied as (a).
7.	Sulphate of potash and magnesia, double manure salt, applied as (b).
8.	High grade sulphate of potash, applied as (a).
9.	High grade sulphate of potash, applied as (b).
10.	No potash.
11.	Carbonate of potash and magnesia.
12.	Wood ashes.
13.	Cottonseed hull ashes.
14.	Nothing.
15.	No potash.
16.	Muriate of potash and lime, 800 pounds lime per acre (only).
17.	Sulphate of potash and lime, 800 pounds lime per acre (only).

18. Muriate of potash and phosphoric acid, sufficient dissolved rock applied to equal the phosphoric acid in wood ashes (only).
19. Muriate of potash, lime (800 pounds lime per acre), and phosphoric acid (sufficient dissolved rock applied to equal the phosphoric acid in wood ashes), (only).
20. Nothing.
21. Wood ashes (only).
22. Stable manure, five tons stable manure per acre (only).
23. Silicate of potash.
24. No potash.
25. No potash.
26. No potash.

General Directions Observed in Connection with the Potash Experiments.

Methods of Applying. All fertilizers shall be applied **broadcast.** On plots marked "as (a)" the fertilizer shall be applied after the ground has been plowed and harrowed once and then harrowed in immediately before planting the crop. Under (b) for spring crop the potash shall be applied in the summer or fall, just after the last crop has been removed from the ground; and for fall crops the potash manure shall be applied in the spring. In case the land is to be plowed several months before planting, apply the potash immediately after plowing, but in case the land is not plowed until just previous to putting in the crop apply the potash from three to six months before planting time.

To all plots except where the words "only" and "nothing" (Plots 14, 16, 17, 18, 19. 20, 21, 22) are used phosphoric acid and nitrogen shall be applied whenever deemed necessary. Applying them at time of applying the potash manures as under (a). All plots receiving the same quantities of phosphoric acid and nitrogen and applying broadcast. The quantity of phosphoric acid and nitrogen applied shall be in such a quantity as circumstances shall seem to warrant. All plots to be seeded to crimson clover whenever possible. The quantities of fertilizer applied gives all plots the same quantity of potash, K_2O. The preparation of the land, the cultivation of the crop, the variety of seed used and all other treatments of the plots were as uniform as was possible to give.

Treatment Given Plots.

There were a few courses pursued in connection with the cropping of these plots that are worthy of special note. In 1897, crimson clover was seeded in the corn at the last working. This gave a good stand and was turned under for the crop of late potatoes.

Previous to planting the potatoes in 1898, there were 50 pounds of

dissolved South Carolina rock applied broadcast to plots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14 and 15, in addition to the potash indicated by the program. The potatoes were not dug until November 7, which was too late to seed anything on the land and it was bare during the winter. The next spring the land was plowed and prepared for cowpeas which were seeded May 24, 1899. The land was plowed after removing the cowpeas and seeded to wheat October 5, 1899. There was no fertilizer applied previous to seeding the wheat.

The potash was applied to all plots previous to each crop which was removed, except the wheat. Phosphoric acid was applied once before—this time as stated above to the potato crop of 1898. There has been no nitrogenous fertilizer applied up to this time.

RESULTS OF EXPERIMENTS.

Time of Application of Potash Fertilizer.

The question of the time of application of commercial fertilizers is one that has been given very little consideration and there is not much data as to experiments upon this subject. The general rule followed by farmers is to apply all commercial fertilizers just previous to planting the crop. This practice has been adopted not only because of convenience but also from the fact that it required the shortest period for the money to be invested in the fertilizer.

In connection with the study of the diffusion and fixation of potash salts, it has been decided that it was generally best to apply them several months before planting the crop, particularly was it best to apply in the fall for spring crops. This advice, of course, had to be varied with the character of the soil. On leachy and light soils, of course, there would be less ability of the soil to fix the potash and hence, if applied long before it was to be used, there would likely be too much loss.

The manufacturers of German potash salts have for a number of years been recommending that muriate of potash be applied to heavy lands in autumn and to light sandy lands in spring. They also recommend that potash salts should always be applied broadcast and plowed down rather than applied on the surface as a top dressing.

In the experiments conducted at the Maryland Station tests were made with kainit, muriate, sulphate and double manure salt, applying them just before planting the crop and three to six months before. In every case where it was practical, the potash salt was applied after plowing and harrowing into the soil. In some cases the fall applications had to be made as a top dressing.

The results of this test are given in Tables VII, VIII and IX. The results, with one exception, all favor applying fertilizers which contain much chlorides, several months before planting the crop and

those having the potash as sulphate at the time of planting the crop. The crop of cowpeas gave results just the reverse. It is a matter of interest to note that the results obtained give about the same figures favoring applying chlorides a considerable time before planting crop as was obtained favoring the application of sulphates at time of planting the crop, that is, by excluding the cowpea figures, there were in five crops 3,527 pounds more product obtained by applying chlorine potash salts three to six months before planting crop and 3,600 pounds more by applying sulphates at time of planting crop.

On soils which contain a certain proportion of sand and clay and with which the potash salts form a sort of cement of mortar, great care should be taken to apply potash salts only in the fall so that freezing and thawing can overcome these conditions. Experiments of Brum-Tickle, Jour. Chem. Soc. London, Dec. 1902, p. 687, showed the best time to apply potash salts for potatoes was in the winter. On new soils rich in peat more potash could be used than with soils longer in cultivation.

TABLE VII.

Comparison of Different Times of Applying Potash Salts.

Grain Crops—Yields per Acre.

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder.	Total yield.	Grain		Straw.	Total yield.
Applied just before planting crop:	Bu.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.	Lbs.
Kainit,	68.1	4,770	3,190	7,960	28.3	1,700	3,500	5,200
Muriate of potash,	79.9	5,590	3,490	9,080	35.7	2,140	5,550	7,690
Douhle manure salt,	67.4	4,720	3,130	7,850	33.0	1,970	3,500	5,470
Sulphate of potash,	74.0	5,180	3,240	8,420	23.3	1,400	4,450	5,850
Average,	72.4	5,065	3,262	8,327	30.1	1,802	4,250	6,052
Applied 3—6 months before planting:								
Kainit,	76.8	5,375	3,460	8,835	34.7	2,080	5,200	7,280
Muriate of potash,	76.3	5,340	3,380	8,720	38.0	2,270	5,550	7,820
Double manure salt,	63.4	4,440	2,960	7,400	23.1	1,390	3,500	4,890
Sulphate of potash,	68.4	4,490	3,100	7,890	23.5	1,410	3,500	4,910
Average,	71.2	4,986	3,230	8,211	29.8	1,787	4,438	6,225
Applied just before planting:								
Average of chlorine salts,	74.0	5,180	3,340	8,520	32.0	1,920	4,525	6,445
Average of sulphate salts,	70.7	4,950	3,185	8,135	28.2	1,685	3,975	5,660
Applied 3—6 months before planting:								
Average of chlorine salts,	76.6	5,357	3,420	8,777	36.4	2,175	5,375	7,550
Average of sulphate salts,	65.9	4,615	3,033	7,645	23.3	1,400	3,500	4,950
Difference in favor of applying chlorine salts 3—6 months before planting crop,	2.6	177	80	257	4.4	255	850	1,105
Difference in favor of applying sulphate salts at time of planting crop,	4.8	335	155	490	4.9	285	475	760

TABLE VIII.

Comparison of Different Times of Applying Potash Salts. (Potato Crops.)

(Yields per Acre.)

Kind of Fertilizer.	1898—Late Potatoes. Large size.	1898—Late Potatoes. Seconds.	1898—Late Potatoes. Total yield.*	1898—Late Potatoes. Total yield.*	1902—Early Potatoes. Large size.	1902—Early Potatoes. Seconds.	1902—Early Potatoes. Total yield.*	1902—Early Potatoes. Total yield.*
	Bu.	Bu.	Bu.	Lbs.	Bu.	Bu.	Bu.	Lbs.
Applied just before planting crop:								
Kainit,	52.7	12.7	71.0	4,260	24.8	20.3	51.0	3,060
Muriate of potash,	65.0	14.0	84.8	5,090	45.0	17.8	66.7	4,000
Soluble manure salt,	61.7	15.0	84.7	5,080	54.0	31.2	90.0	5,400
Sulphate of potash,	65.5	18.8	93.5	5,610	46.2	25.3	74.7	4,490
Average,	61.2	15.1	83.5	5,010	42.5	23.6	70.6	4,236
Applied 3—6 months before planting:								
Kainit,	61.5	19.3	87.0	5,220	38.5	19.8	62.2	5,730
Muriate of potash,	77.0	13.7	97.0	5,820	44.0	24.8	74.9	4,495
Double manure salt,	44.7	12.5	65.0	3,900	55.5	28.5	87.8	5,270
Sulphate of potash,	58.8	19.3	84.8	5,090	33.5	20.3	57.0	3,420
Average,	60.5	16.2	83.5	5,008	42.9	23.4	70.5	4,230
Applied just before planting:								
Average of chlorine salts,	58.8	13.3	77.9	4,675	34.9	19.0	58.8	3,530
Average of sulphate salts,	63.6	16.9	89.1	5,345	50.1	28.2	82.3	4,945
Applied 3—6 months before planting:								
Average of chlorine salts,	69.2	16.5	92.0	5,520	41.2	22.3	68.5	4,112
Average of sulphate salts,	51.7	15.7	74.9	4,495	44.5	24.4	72.4	4,345
Difference in favor of applying chlorine salts 3—6 months before planting crop,	10.4	3.2	14.1	845	6.3	3.3	9.7	582
Difference in favor of applying sulphates at time of planting,	11.9	1.2	14.2	850	5.6	3.8	9.9	600

*Including culls.

TABLE IX.

Comparison of Different Times of Applying Potash Salts. (Hay Crop and Summary of all Crops.)

(Yields per Acre.)

Kind of Fertilizer.	1899—Cowpeas.	1901—Hay.	Total yield of six crops.
	Lbs.	Lbs.	Lbs.
Applied just before planting crop:			
Kainit,	4,800	3,800	29,080
Muriate of potash,	5,700	4,550	36,110
Double manure salt,	5,750	5,600	35,150
Sulphate of potash,	6,200	5,050	35,620
Average,	5,612	4,570	33,990
Applied 3 to 6 months before planting crop:			
Kainit,	4,800	4,400	34,440
Muriate of potash,	4,900	5,250	37,005
Double manure salt,	7,700	5,150	34,310
Sulphate of potash,	6,750	3,700	31,760
Average,	6,037	4,625	34,379
Applied just before planting crop:			
Average of chlorine salts,	5,250	4,175	32,595
Average of sulphate salts,	5,975	5,325	35,385
Applied 3 to 6 months before planting crop:			
Average of chlorine salt,	4,850	4,825	35,722
Average of sulphate salt,	7,225	4,425	33,035
Difference in favor of applying chlorine salts 3 to 6 months before planting crop,	(—400)	650	3,127
Eliminating cowpea crop,	....	....	3,527
Difference in favor of applying sulphate salts at time of planting crop,	(—1,250)	900	2,350
Eliminating cowpea crop,	....	....	3,600

THE EFFECTS OF DIFFERENT POTASH FERTILIZERS ON YIELD.

German Potash Salts.

In Table X are given the results of the average of the two plots fertilized with different kinds of German Potash Salts and in Table XI a summary of those obtained by applying the salts at the most favorable time, as shown by Tables VII, VIII and IX.

None of these results show a very marked increase of product as a result of potash fertilization, yet they do point toward muriate as being the most efficient in producing an increase of crop. Sul-

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phate of potash stands second, carbonate of potash and kainit in these tables indicate negative results.

The effect of potash in increasing crop of course will vary considerable with different classes of soils.

TABLE X.

Comparison of German Potash Salts. (Average of two Plots Each). (Yields per Acre).

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder.	Total yield.	Grain.		Straw.	Total yield.
	Bu.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.	Lbs.
Kainit,	72.5	5,072	3,325	8,397	31.5	1,890	4,350	6,240
Muriate of potash,	78.1	5,465	3,435	8,900	36.7	2,205	5,550	7,755
Sulphate of potash and magnesia (double manure salt),	65.4	4,580	3,045	7,625	28.0	1,680	3,500	5,180
Sulphate of potash (high grade),	71.1	4,985	3,170	8,155	23.4	1,405	3,975	5,380
Carbonate of potash and magnesia,	71.6	5,010	3,340	8,350	26.5	1,590	4,000	5,590
Nothing,	69.5	4,865	3,140	8,005	27.9	1,675	4,550	6,225

*Allowing 70 pounds of corn ears to bushel.

Kind of Fertilizer.	1898—Late Potatoes.				1902—Early Potatoes.			
	Large potatoes.	Seconds.	Total yield.*	Total yield.*	Large potatoes.	Seconds.	Total yield.*	Total yield.*
	Bu.	Bu.	Bu.	Lbs.	Bu.	Bu.	Bu.	Lbs.
Kainit,	57.0	16.0	79.0	4.740	31.1	20.5	56.6	3,395
Muriate of potash,	71.0	13.8	90.9	5,455	44.5	21.3	70.8	4,250
Sulphate of potash and magnesia (double manure salt),	53.2	13.8	74.8	4,490	54.7	29.8	88.9	5,335
Sulphate of potash (high grade),	62.2	19.0	89.2	5,350	39.9	22.8	65.9	3,995
Carbonate of potash,	56.0	19.8	84.8	5,090	34.5	21.7	59.5	3,570
Nothing,	57.8	14.8	80.5	4.830	38.5	25.9	69.0	4,140

*Including culls.

Kind of Fertilizer.	1899—Cowpeas.	1901—Hay.	Total yield of six crops.
	Lbs.	Lbs.	Lbs.
Kainit,	4,800	4,100	31,760
Muriate of potash,	5,300	4,900	36,557
Sulphate of potash and magnesia,	6,725	5,650	34,730
Sulphate of potash (high grade),	6,475	4,375	33,690
Carbonate of potash and magnesia,	7,450	4,000	34,050
Nothing,	6,675	4,950	34,825

TABLE XI.

Comparison of Yields with Different Potash Salts. Applied at the Season Which Gave Best Returns.

(Yields per Acre).

Kind of Fertilizer.	1897—Corn.	1898—Potatoes.	1899—Cowpeas.	1900—Wheat.	1901—Hay.	1902—Potatoes.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Kainit,	8,830	5,220	4,800	7,280	4,400	3,730	34,440
Muriate of potash,	8,720	5,820	4,900	7,820	5,250	4,495	37,005
Double manure salt,	7,850	5,080	5,750	5,740	5,600	5,400	35,150
Sulphate of potash,	8,420	5,610	6,200	5,850	5,050	4,490	35,620
Nothing (average of 2 plots),	8,005	6,225	4,830	4,140	6,675	4,950	34,825

Experiments With Silicate of Potash.

This is a Stassfurt preparation that has been but recently manufactured with an idea of using it as a source of potash for tobacco. It has not been placed regularly on the market in this country; nevertheless, it was thought that it might be interesting to test it in comparison with other sources of potash. The potash plots being a little uneven it was not thought quite fair to compare this with the other German salts.

In Table XII will be found the results of the use of silicate of potash. Wood ashes are also given, as this was the only other source of potash which contained any considerable quantity of potash insoluble in water. It will be noticed that the silicate produced a marked increase in yield with all crops, though not quite

as great as the wood ashes plot which was beside it. Potatoes and grass seemed to have the greatest relative ability to feed upon the silicate.

Experiments with Wood Ashes and Stable Manure.

In Table XI will be found the yields produced by an application of stable manure and wood ashes. These results show that the stable manure was particularly efficient in increasing the yield, which would seem to indicate that this land was lacking in a physical character which the organic matter can produce to better advantage than the caustic principle of the wood ashes.

TABLE XII.

Results of the Use of Silicate of Potash and Stable Manure.

(Yields per Acre).

Kind of Fertilizer.	1897—Corn.				1900—Wheat.			
	Grain.		Fodder.	Total yield.	Grain.		Straw.	Total yield.
	Bu.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.	Lbs.
Nothing (average of plots 20, 24, 25, 26),	54.1	3,790	2,780	6,570	22.9	1,370	3,162	4,532
Silicate of potash,	58.4	4,090	2,770	6,860	25.0	1,480	3,900	5,380
Wood ashes,	66.3	4,640	3,530	8,170	28.0	1,680	4,000	5,680
Stable manure,	78.9	5,520	2,770	8,290	37.0	2,220	5,350	7,570

Kind of Fertilizer.	1898—Late Potatoes.				1902—Early Potatoes.			
	Large size.	Seconds.	Total yield.*	Total yield.*	Large size.	Seconds.	Total yield.*	Total yield.*
	Bu.	Bu.	Bu.	Lbs.	Bu.	Bu.	Bu.	Lbs.
Nothing (average, plots 20, 24, 25, 26),	22.5	15.9	48.1	2,887	19.9	10.7	37.1	2,225
Silicate of potash,	44.2	15.7	69.0	4,140	29.3	13.2	47.5	2,850
Wood ashes,	49.7	14.5	72.3	4,340	40.8	14.2	61.3	3,680
Stable manure,	58.3	18.8	86.5	5,190	47.0	18.2	70.8	4,250

*Including culls.

Kind of Fertilizer.	1899—Cowpeas.	1901—Hay.	Total, 6 crops.
	Lbs.	Lbs.	Lbs.
Nothing,	5,050	2,862	24,152
Silicate of potash,	5,400	4,500	29,130
Wood ashes,	6,500	4,750	33,130
Stable manure,	5,350	5,200	35,850

Experiments with Different Sources of Carbonate of Potash.

In Table XIII is given the results of the use of the different sources of carbonate of potash which are available for fertilizing purposes.

The results show that all the forms were quite effective in increasing the yields. Cottonseed hull ashes proved the most effective but, as has been previously stated, this supply is quite limited and does not come into the general market. The carbonate of potash and magnesia, which is one of the Stassfurt productions, did not seem quite as active at the start, but with the six crops it produced a larger increase than wood ashes. This result is particularly interesting as the supply of wood ashes, which is so highly prized, is becoming scarcer each year and consequently if the carbonate of potash and magnesia can be placed on the market at a reasonable price it may be able to supply many with a carbonate of potash who now cannot get wood ashes. It will be noted that the carbonate of potash and magnesia produced on the six crops over double as much increase as was produced by the muriate of potash when compared to their respective nothing plots.

TABLE XIII.

Comparison of Different Sources of Carbonate of Potash.

(Yields per Acre).

Kind of Fertilizer.	1897—Corn.				1900—Wheat.			
	Grain.		Fodder.	Total yield.	Grain.		Straw.	Total yield.
	Bu.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.	Lbs.
Carbonate of potash and magnesia,	71.6	5,010	3,340	8,350	26.5	1,590	4,000	5,590
Wood ashes,	75.7	5,300	3,360	8,660	26.1	1,570	3,950	5,520
Cottonseed hull ashes,	74.0	5,180	3,450	8,630	30.8	1,850	4,800	6,650
Nothing (average of plots 10 and 14),	68.2	4,775	3,030	7,805	19.0	1,135	3,325	4,460

Kind of Fertilizer.	1898—Late Potatoes.				1902—Early Potatoes.			
	Large size.	Seconds.	Total yield.*	Total yield.*	Large size.	Seconds.	Total yield.*	Total yield.*
	Bu.	Bu.	Bu.	Lbs.	Bu.	Bu.	Bu.	Lbs.
Carbonate of potash and magnesia,	56.9	19.8	84.8	5,090	34.5	21.7	59.5	3,570
Wood ashes,	50.0	17.0	74.8	4,490	31.3	21.1	57.3	3,440
Cottonseed hull ashes.	65.3	19.3	95.8	5,750	46.3	14.5	66.6	3,995
Nothing (average of plots 10 and 14),	41.2	14.3	64.7	3,880	28.7	17.3	50.1	3,010

*Including culls.

Kind of Fertilizer.	1899—Cowpeas.	1901—Hay.	Total yield, 6 crops.
	Lbs.	Lbs.	Lbs.
Carbonate of potash and magnesia,	7,450	4,000	34,050
Wood ashes,	5,850	4,230	32,190
Cottonseed hull ashes,	7,600	3,800	36,425
Nothing (average of plots 10 and 14),	4,925	3,675	27,755

Testing Lime and Potash in Combination.

It has already been pointed out that lime is valuable in rendering potash available which is already in the soil, by producing the conditions favorable for the formation of double silicates. Lime performs this same function in connection with potash salts which are applied to soils.

In certain soils, potash, as well as other salts, such as salt and nitrate of soda produce a marked physical change by cementing or hardening of the soil. This interferes with the circulation of the air and moisture and with the distribution of the rootlets of crops. This unfavorable condition is partially due to the hygroscopic nature of the salts. On soils of this nature lime has the power to counteract these harmful results; therefore should always be applied in conjunction with potash salt.

Again, it must not be forgotten that the addition of potash salts to the soil has a tendency to cause a loss of lime, from the fact that in the mutual reactions which take place in the soil, alkaline silicates are formed from the sulphates and chlorides and a quantity of lime corresponding to these is converted into sulphates and

chlorides. These lime salts are subject to loss by washing and leaching—particularly is this true of the chlorides. Hence this condition is more likely to follow the use of kainit and muriate of potash. By experiment it has been shown that 100 pounds of kainit applied to a soil may cause a loss of 40 parts of lime.

Experiments conducted by the Massachusetts Station have shown that if muriate of potash is used without proper precaution on soils with a limited supply of lime the full benefit of the potash would not be obtained because the lime of the soil was converted into a soluble form which was either washed out in the drainage or it accumulated in the upper soil and poisoned the plants. It was observed that oats, rye and soja beans grown on soil which had received applications of muriate of potash for a number of years in succession continued to decrease in yield and were unhealthy in appearance. This condition was attributed to the action of the muriate on the lime of the soil, and an examination of the drainage water of the soil showed a considerable quantity of chloride of lime and much more than where sulphate of potash was used. On soils that have a good drainage, liberal applications of lime will overcome any harmful effects of the above nature attending the application of muriates, but in soils that are not well drained it would be best to depend upon some other source of potash.

With the idea of studying the desirability of the use of lime with potash salts, some combined applications were made in the series of experiments conducted at the Maryland Station. These tests were also conducted with an idea that they might throw some light upon whether wood ashes were chiefly valuable for the potash or the lime which they furnished. The results of the tests made in this connection are given in Table XIV.

Comparing the results given in Table XIV with those given in Table X, it will be seen that on this soil the use of lime with muriate and sulphate did not prove of any material advantage.

The results given in Table XIV show that the use of lime with sulphate of potash was more effective in increasing yields than wood ashes, while the muriate of potash and lime was less so. Supplementing muriate with phosphoric acid and with lime and phosphate in combination gave rather negative results, at least nothing from which satisfactory conclusions could be drawn.

TABLE XIV.

Showing the Results of Using Lime and Phosphoric Acid in Combination with Potash Salts.

(Yields per Acre.)

Kind of Fertilizer.	1897—Corn. Grain.		Fodder.	Total yield.	1900—Wheat. Grain.		Straw.	Total yield.
	Bu.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.	Lbs.
Nothing (average of plots 14, 15, 20),	65.0	4,547	3,090	7,637	21.7	1,298	3,600	4,898
Wood ashes (average of plots 12, 21),	71.0	4,970	3,445	8,415	27.0	1,625	3,975	5,600
Muriate of potash and lime, ...	69.9	4,890	3,200	8,090	21.0	1,240	3,500	4,740
Sulphate of potash and lime, ...	75.0	5,250	3,320	8,570	23.3	1,400	4,000	5,400
Muriate of potash and phosphoric acid, ...	70.3	4,920	3,060	7,980	27.0	1,610	4,050	5,660
Muriate, lime and phosphoric acid, .	65.9	4,610	2,530	7,140	27.0	1,620	4,050	5,670

Kind of Fertilizer.	1898—Late Potatoes. Large size.	Seconds.	Total yield.*	Total yield.*	1902—Early Potatoes. Large size.	Seconds.	Total yield.*	Total yield.*
	Bu.	Bu.	Bu.	Lbs.	Bu.	Bu.	Bu.	Lbs.
Nothing, ...	39.7	14.9	64.1	3,847	29.7	12.9	46.7	2,800
Wood ashes, ...	49.9	15.7	73.5	4,415	36.0	17.2	59.3	3,560
Muriate of potash and lime, ...	49.3	17.7	91.7	5,500	19.0	14.0	38.3	2,300
Sulphate of potash and lime, ...	43.3	18.2	71.8	4,310	26.7	12.8	45.3	2,720
Muriate of potash and phosphoric acid, ...	40.8	17.0	69.0	4,140	32.3	14.2	53.3	3,200
Muriate, lime and phosphoric acid,	39.2	18.2	67.8	4,060	12.8	12.8	31.0	1,860

*Including culls.

Kind of Fertilizer.	1899—Cowpeas.	1901—Hay.	Total, 6 crops.
	Lbs.	Lbs.	Lbs.
Nothing, ...	5,600	3,600	28,380
Wood ashes, ...	6,175	4,490	32,660
Muriate of potash and lime, ...	5,900	4,250	30,830
Sulphate of potash and lime, ...	8,050	6,050	35,100
Muriate of potash and phosphoric acid, ...	5,600	5,200	31,780
Muriate, lime and phosphoric acid, ...	5,500	5,150	29,380

Conditions Influencing the Effectiveness of Potash.

The experiments reported upon in this bulletin, as well as the results of those of the phosphoric acid and nitrogen series of plots which are parallel to the potash series and on about the same character of land, show quite clearly that this soil is not as deficient in potash as it is in phosphoric acid. It is also evident that the soil lacks organic matter and nitrogen.

These facts show that for marked results in increased yields with potash the ration of plant foods should be balanced and the soil should also be put in a better mechanical condition. These conditions were reorganized, in a measure, from the beginning of the tests, but it was not deemed desirable to provide them at the start. However, this part of the work will be given due attention in the continuation of these studies.

The Relation of Potash Fertilizers to Quality of Crop.

In the experiments reported upon in the preceeding pages it was not possible to observe any special effect of the fertilizers used upon the quality of the product; the Maryland Station made extensive experiments upon the effect of potash fertilizers upon tobacco, the results of which are reported in its Bulletin No. 26, and upon tomatoes and reported in its Bulletin No. 11. It was shown that high grade sulphate of potash produced the best tobacco and carbonate of potash furnished by cottonseed hull ashes the next best. All potash salts which contained either much chlorine or magnesia produced a tobacco of poor quality which cured badly and a very poor burning quality.

In the tomato experiments, potash had a marked effect in increasing the yield and quality of the tomatoes. Tomatoes fertilized with potash were more solid, yet a little more acid.

The Kentucky Station, Bulletin No. 22, p. 16, notes that sulphate of potash produced not only a large yield, but also a dryer, larger and smoother potato than any other salt.

Experiments by the Kentucky Station, Bulletin 28, p. 13, showed that while sulphate and muriate had about the same effect in increasing the yield of tobacco, sulphate gave best quality. Kentucky Bulletin 27, states that sulphate and muriate produced about the same effect on hemp.

Kentucky Bulletin 45, states that the effect of potash fertilizers showed four seasons after application.

Massachusetts Station, Annual Report, 1893, p. 155, states that sulphate gave results decidedly in favor of sulphate both for yield and quality.

Experiments conducted by both the Massachusetts and New Hampshire Stations proved that the average mixed fertilizer contained too little potash for general farm crops on New England soils, and that muriate of potash was decidely unfavorable to starch formation in potatoes.

Experiments conducted by the Massachusetts Station, Bulletin 15, p. 7, on carnations, roses and lettuce, proved that sulphate was much superior to muriate for these crops. It gave more and better bloom and the plants were freer from mildew. It has been observed by some growers that potash has a tendency to produce a higher color in fruit and sometimes in flowers.

Experiments conducted by Pfeiffer, Lemmermann and Schillbach (Landw. versuchs-Stat., 1897, p. 349-385), on the effects of "Different Potash Salts on the Composition of Potatoes" found that chloride of potash and sulphate of potash had about the same effect on the growth and composition of potatoes while the same amount of potash in the crude salts containing much chlorides caused a slight decrease in the amount of starch produced. This was attributed to the magnesium and other chlorides in the crude salts. A low percentage of chlorine in the soil seemed a disadvantage to the growth of potatoes. Unusually high content of starch was sometimes accompanied by a high content of chlorine in the tubers and vines.

INJURIOUS EFFECTS OF POTASH SALTS.

From what has already been said it is evident that applications of potash are sometimes harmful, at least affect crops unfavorably. The cause of this injury seems to reside chiefly in the chlorides which many of the crude potash salts contain. The harmful results are sometimes manifested by decreasing the yield, but more generally by a deterioration in quality of the product. For instance, when tobacco is fertilized with crude potash salts, muriate of potash or any salt containing considerable chlorine, the burning qualities are considerably impaired. This seems to be due to the fact that the tobacco plant will take up an excess of chlorine and prevent the leaf from burning because of the easy fusibility of chlorine.

An excess of chlorine has also been found to lessen the sugar content of grapes and the starch content of potatoes and sometimes the sugar content of sugar beets.

Other injurious influences in the use of potash salts which occur under some conditions has already been pointed out, such as the causing the supply of lime to be decreased and producing an undesirable physical condition of the soil.

Miscellaneous Indirect Effects of Potash Salts.

Besides the value of potash salts by acting as a direct food for plants there are a number of advantages attending their application which are worthy of notice and which may be termed indirect effects.

Effect on Nitrifying Organisms.

Under some circumstances the application of large quantities of potash has a tendency to retard the process of nitrification; but from experiments conducted by Prof. F. D. Chester, reported in Bulletin No. 98, Pennsylvania Department of Agriculture, p. 57, the author claims that the action of potash salts is to combine with the humates of the soil and form compounds which are readily nitrificable. Dumont found that potash salts alone or mixed with carbonate of lime increased nitrification in soils rich in humus. It has also been shown that nitrifying organisms cannot multiply except there is present, among other elements, lime, phosphoric acid and potash. Nitrification is accordingly aided by the application of mineral fertilizers. These facts seem to add force to the requirements already stated that there should always be an abundance of lime and vegetable matter in soils which are liberally fertilized with potash.

For Preservation of Manure.

All kinds of animal manure when exposed to the elements without care undergo a more or less rapid decomposition which is attended by a considerable loss of organic matter. In the decomposition of the organic matter there is not only a loss of a considerable amount of humus forming material but also of nitrogen. It has been estimated that as manure is commonly cared for the loss amounts to one ton of organic matter and is equivalent to the nitrogen contained in 200 pounds of nitrate of soda per year per horse.

It has been found that potash salts, particularly kainit, has the property of absorbing and retaining most of the nitrogen and also preventing harmful fermentation and loss of organic matter. For this purpose the kainit is sprinkled daily in the stable at the rate of one and one-half to two pounds per full grown animal. This process produces not only the above named advantages but also enriches the manure in potash and makes it more nearly a balanced plant food.

Plaster, dissolved phosphates and earth are also available for preserving manure.

Part of the value of kainit as a preserver of manure no doubt rests in its germicidal properties when in the concentrated form; but when the manure is spread over the land and diluted and aerated the activity of the ferments seem to be restored and inaugurated. This is particularly true on light sandy soils.

Effects on the Conservation of Soil Moisture.

Potash salts through their hygroscopic nature have the ability to keep soils moist in dry seasons. Dr. H. W. Wiley, U. S. Dept. Agrl., gives the results of some determinations on the moisture content in two samples from the same soil, one with and one without the application of potash. The results were as follows:

	With kainit, per cent. moisture.	Without kainit, per cent. moisture.
March 18,	15.3	15.2
June 1,	8.5	1.8
August 1,	5.0	1.3
October 18,	13.3	1.9

Dr. Wiley remarks on this as follows: "From the above table the marked difference in the moisture in the samples during the summer and autumn is quite instructive. It is true that a soil impregnated with kainit would give up its moisture less rapidly to a growing plant than one free of that salt; but there is no doubt that a soil containing 13 per cent. moisture, would be able to supply water to a plant more readily than a soil free of it and containing only 2 per cent. of moisture."

There is, however, another phase of the question and that is that the soil water where the kainit was applied may be so charged with soluble salts that it would prove detrimental or, in a sense, poisonous to the plant and thus cause a crop to suffer more from this cause than it would from lack of water. The writer has observed this condition on two or three occasions with crops on the Station farm.

Potash salts have been found to influence the upward movement of water in the soil. King, Wisconsin Experiment Station Report, 1893, p. 99, states that .08 per cent. nitrate of potash in a sandy soil increased the upward movement of water 22 per cent.

Protection Against Frost.

The presence of a considerable quantity of potash salts in the soil and their faculty of holding moisture will have a tendency to retard evaporation of moisture from the soil and thus often either entirely prevent a frost or at least make it lighter than it would otherwise have been.

Potash Salts as Insecticides and Fungicides.

It has frequently been observed that potash salts will prevent the ravages of insects and also either prevent or lessen the effects of some plant diseases.

Kainit has given better results for these purposes than any other potash salt. Its greatest usefulness in this character as far as observed has been with pests that live in the ground and around the roots of plants, such as root lice, wire-worms and cut-worms.

Dr. J. B. Smith, entomologist, gives in the Bulletins and Reports of the New Jersey Experiment Station, the results of numerous experiments and observations showing beneficial effects of the use of kainit in preventing root louse on corn, cut-worm and wire-worm on corn, wire-worm on potatoes, black aphis on the roots of peach trees, and cabbage maggots. He has also found it useful in preventing the breeding of the rose chafer.

Atkinson in Alabama, Dabney in North Carolina, Pamnell in Texas, have all made experiments showing the value of applications of kainit in controlling cotton blight, cotton rust and cotton root rot. Hilgard has found that potash fertilizers will aid in mitigating the effects of the phylloxera on the grape. Numerous observations have been recorded as to the value of potash in overcoming certain yellow conditions or appearances of the leaves of peach trees and bring them back to a healthy productive condition again. This, however, is not the true "yellows" of the peach. Where the kainit or other potash salt is used for the purpose of its insecticide or fungicide properties, it is necessary to apply it much heavier than would be necessary for simple fertilizing purposes unless, as is sometimes the case, that very small applications in the hill or drill will give the desired protection.